SECTION 23 09 23.01 29

DIRECT DIGITAL CONTROL FOR HVAC

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D 1693	(2008) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D 635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2000; R 2015) Standard for Industrial Control and Systems: General Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1585	(1998; Rev thru Feb 2004) UL Standard for Safety Class 2 and Class 3 Transformers - Fourth Edition
UL 94	(2013; Reprint Jul 2015) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 GENERAL REQUIREMENTS

The DDC system will be a Siemens APOGEE proprietary P2 communication protocol system provided by Siemens Industry, Inc. to accommodate a seamless extension of the existing site-wide DDC system at Clear AFS without the use of gateways, drivers, or protocol converters.

Siemens Industry, Inc. shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems as herein specified.

The software programming and graphics for all other buildings in CP-2 (FY17) and LES shall be consistence with MCF programming. However, it will be the responbsibility under each design package.

Point list provided in the drawings are minimum required points. Provide additional points to comply with sequence and diagram requirements.

The direct digital control (DDC) shall be a complete system suitable for the heating, ventilating and air-conditioning (HVAC) system.

Refer to Section 25 10 11.01 00 POWER CONTROL AND MONITORING SYSTEM (PCMS) for additional PCMS integration requirements. The Contractor is responsible for integrating the PCMS. The interconnection to the PCMS is via the gateways as shown on the drawings.

1.2.1 Verification of Dimensions

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

1.2.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

1.2.3 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected from power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.2.4 DDC System Network Accessibility

Where the systems to be controlled by the DDC system are located in multiple mechanical rooms, each mechanical room shall have at least one communication port for the portable workstation/tester. DDC controllers shall be located in the same room as the equipment being controlled or in an adjacent space which has direct access to the equipment room.

1.2.5 System Accuracy and Display

The system shall maintain an end-to-end accuracy for one year from sensor to operator's console display for the applications specified and shall display the value as specified. Each temperature shall be displayed and printed to nearest 0.1 degree F.

1.2.5.1 Space Temperature

Space temperature with a range of 55 to 85 degrees F plus or minus 0.75 degree F for conditioned space; 10 to 130 degrees F plus or minus 1 degree F for unconditioned space.

1.2.5.2 Duct Temperature

Duct temperature with a range of 40 to 140 degrees F plus or minus 2 degrees F.

1.2.5.3 Outside Air Temperature

Outside air (OA) temperature with a range of minus 50 to plus 130 degrees F plus or minus 2 degrees F; with a subrange of 30 to 100 degrees F plus or minus 1 degree F.

1.2.5.4 Water Temperature

Water temperature with a range of 30 to 100 degrees F plus or minus 0.75 degree F; the range of 100 to 250 degrees F plus or minus 2 degrees F; and water temperatures for the purpose of performing Btu calculations using differential temperatures to plus or minus 0.5 degree F using matched sensors.

1.2.5.5 High Temperature

High temperature with a range of 200 to 500 degrees F plus or minus 2.0 degrees F.

1.2.5.6 Relative Humidity

Relative humidity, within a range of 20 to 80 percent, plus or minus 6.0 percent of range (display and print to nearest 1.0 percent).

1.2.5.7 Pressure

Pressure with a range for the specific application plus or minus 2.0 percent of range (display and print to nearest psi.)

1.2.5.8 Flow

Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of thermal calculations to plus or minus 2.0 percent of actual flow (display and print to nearest unit, such as gallons per minute).

1.2.5.9 KWh and kW Demand

KWh and kW demand with a range for the specific application plus or minus 1.0 percent of reading (display and print to nearest kWh or kW).

1.2.5.10 Analog Value Input

An analog value input to the system's equipment via an AI with a maximum error of 0.50 percent of range, not including the sensor or transmitter error. This accuracy shall be maintained over the specified environmental conditions.

1.2.6 Redundancy

BMS system will be configured with redundant controllers and network switches for critical systems as indicated on the plans. For mechanical systems with primary (A), (B), and redundant (C) systems, completely separate controllers and network switches will be used for each system. That is, there will be a primary (A) and (B) controllers, and a redundant (C) controller and network switch as required.

Ethernet switch shall be provided inside each DDC control panel to allow controller to switch fail over.

1.2.7 Graphics

Provide graphics for each mechanical or other system controlled and/or monitored by the BMS, each HVAC terminal unit and/or temperature control zone, and each floor plan. Graphics are defined as the combination of background drawings and dynamic layers used by the graphics application within the BMS server software.

For each mechanical or other system controlled and/or monitored by the BMS, and for each typical terminal unit or zone application, provide background drawings similar to the associated BMS shop dwg(s) illustrating the system in schematic, flow diagram format, along with relevant BMS system devices. Provide background drawings of floor plans of the facility including room numbers. provide background drawings for table of contents pages representing all system graphics with a site-wise home page with an organizational structure for future buildings.

For each system or terminal unit/zone template graphic, provide all associated physical points in the display to be dynamically updated and provide links as needed to navigate to other relevant graphics and/or appropriate home or table of contents pages. Also provide relevant virtual points including setpoints, overrides, or other points as needed for normal operator interaction with the system. For floorplans, provide all room-based temperature, humidity, or other environmental sensors or wall-mounted manually activated switch points in the display to be dynamically updated and provide links as needed to navigate to other relevant graphics and/or appropriate home or table of contents pages.

All physical points are to be represented on at least one graphic.

Provide graphics specific for battleshort mode and HEMP mode.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. Submittals with an "S" designation following the "G" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29.01 00 SUSTAINABILITY REPORTING. Other designations following the "G" designation identify the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00.01 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Building Management System; G JBRC

Drawings shall be on 11 by 17 inch sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall have a unique identifier as shown. The Building Management System Drawings shall be delivered together as a complete submittal. Deviations must be approved by the Contracting Officer. Drawings shall be submitted along with Submittal SD-03, Product Data.

a. Building Management System Drawings shall include the following:

Element One: Drawing Index, Building Management System Legend.

Element Two: Valve Schedule, Damper Schedule.

Element Four: Control System Schematic and Equipment Schedule.

Element Five: Sequence of Operation and Data Terminal Strip Layout.

Element Six: Control Loop Wiring Diagrams.

Element Seven: Motor Starter and Relay Wiring Diagram.

Element Eight: Communication Network and Block Diagram.

Element Nine: DDC Panel Installation and Block Diagram.

Element Ten: Graphics User Interface Screens: to be submitted as a separate submittal item

b. The Building Management System Drawing Index shall show the name and number of the building, military site, State or other similar designation, and Country. The Drawing Index shall list Building Management System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The Building Management System Legend shall show generic symbols and the name of devices shown on the Building Management System Drawings.

c. The valve schedule shall include each valve's unique identifier, size, flow coefficient Cv, pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure data, dimensions, and access and clearance requirements data. Valve schedules may be submitted in advance but shall be included in the complete submittal.

d. The Building Management System schematics shall be in the form shown, and shall show all control and mechanical devices associated with the HVAC system. A system schematic drawing shall be submitted for each HVAC system.

e. The Building Management System equipment Schedule shall be in the form shown. All devices shown on the drawings having unique identifiers shall be referenced in the equipment schedule. Information to be included in the equipment schedule shall be the device unique identifier, and additional important parameters (i.e., output range). An equipment schedule shall be submitted for each HVAC system.

f. The Building Management System sequence of operation shall reflect the language and format of this specification, and shall refer to the devices by their unique identifiers as shown. No operational deviations from specified sequences will be permitted without prior written approval of the Contracting Officer. Sequences of operation shall be submitted for each Building Management System including each type of terminal unit control system.

g. The Building Management System wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to HVAC control panel terminal blocks and to the identified terminals of devices, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for Building Management Systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, HVAC system control panel, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each Building Management System.

SD-03 Product Data

Service Organizations; G JRC

Six copies of a list of service organizations qualified to service the Building Management System. The list shall include the service organization name, address, technical point of contact and telephone number, and contractual point of contact and telephone number.

Equipment Compliance Booklet; G JRC

The Building Management System Equipment Compliance Booklet (ECB) shall be in booklet form and indexed, with numbered tabs separating the information on each device. It shall consist of, but not be limited to, data sheets and catalog cuts which document compliance of all devices and components with the specifications. The ECB shall be indexed in alphabetical order by the unique identifiers. Devices and components which do not have unique identifiers shall follow the devices and components with unique identifiers and shall be indexed in alphabetical order according to their functional name. The ECB shall include a Bill of Materials for each Building Management System. The Bill of Materials shall function as the Table of Contents for the ECB and shall include the device's unique identifier, device function, manufacturer, model/part/catalog number used for ordering, and tab number where the device information is located in the ECB. The ECB shall be submitted along with Submittal SD-02, Shop Drawings.

Commissioning Procedures; G C

Six copies of the Building Management System commissioning procedures, in booklet form and indexed, 60 days prior to the scheduled start of commissioning. Commissioning procedures shall be provided for each Building Management System, and for each type of terminal unit control system. The Commissioning procedures shall reflect the format and language of this specification, and refer to devices by their unique identifiers as shown. The Commissioning procedures shall be specific for each HVAC system, and shall give detailed step-by-step procedures for commissioning of the system.

a. The Commissioning procedures shall include detailed, product specific set-up procedures, configuration procedures, adjustment procedures, and calibration procedures for each device. Where the detailed product specific commissioning procedures are included in manufacturer supplied manuals, reference may be made in the Building Management System commissioning procedures to the manuals.

Performance Verification Test Procedures; G C

Six copies of the Building Management System Performance Verification Test Procedures, in booklet form and indexed, 60 days before the Contractor's scheduled test dates. The performance verification test procedures shall refer to the devices by their unique identifiers as shown, shall explain, step-by-step, the actions and expected results that will demonstrate that the Building Management System performs in accordance with the sequences of operation, and other contract documents. An Building Management System performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

Training; G C

An outline for the Building Management System training course with a proposed time schedule. Approval of the planned training schedule shall be obtained from the Government at least 60 days prior to the start of the training. Six copies of Building Management System training course material 30 days prior to the scheduled start of the training course. The training course material shall include the operation manual, maintenance and repair manual, and paper copies of overheads used in the course.

SD-06 Test Reports

Commissioning Report; G C

Six copies of the Building Management System Commissioning Report, in booklet form and indexed, within 30 days after completion of the system commissioning. The commissioning report shall include data collected during the Building Management System commissioning procedures and shall follow the format of the commissioning procedures. The commissioning report shall include all configuration checksheets with final values listed for all parameters, setpoints, P, I, D setting constants, calibration data for all devices, results of adjustments, and results of testing.

Performance Verification Test; G C

Six copies of the Building Management System Performance Verification Test Report, in booklet form and indexed, within 30 days after completion of the test. The Building Management System performance verification test report shall include data collected during the Building Management System performance verification test. The original copies of all data gathered during the performance verification test shall be turned over to the Government after Government approval of the test results.

SD-10 Operation and Maintenance Data

Operation Manual; G C

Maintenance and Repair Manual; G C

Six copies of the Building Management System Operation Manual and Building Management System Maintenance and Repair Manual, for each Building Management System, 30 days before the date scheduled for the training course. Submit in accordance with Section 01 78 23.01 00 OPERATION AND MAINTENANCE DATA.

1.4 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.5 OPERATION MANUAL

An Building Management System operation manual in indexed booklet form shall be provided for each Building Management System. The operation manual shall include the Building Management System sequence of operation, and procedures for the HVAC system start-up, operation and shut-down. The operation manual shall include as-built Building Management System detail drawings. The operation manual shall include the as-built configuration checksheets, the procedures for changing Building Management System setpoints, and the procedures for placing HVAC system controllers in the manual control mode.

a. The procedures for changing Building Management System setpoints shall describe the step-by-step procedures required to change the process variable setpoints, the alarm setpoints, the bias settings, and setpoint reset schedules.

b. The procedures for placing HVAC system controllers in the manual control mode shall describe step-by-step procedures required to obtain manual control of each controlled device and to manually adjust their positions.

1.6 MAINTENANCE AND REPAIR MANUAL

An Building Management System maintenance and repair manual in indexed booklet form in hardback binders shall be provided for each Building Management System. The maintenance and repair manual shall include the routine maintenance checklist, a recommended repair methods list, a list of recommended maintenance and repair tools, the qualified service organizations list, the as-built commissioning procedures and report, the as-built performance verification test procedures and report, and the as-built equipment data booklet.

a. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all devices listed in the equipment compliance booklet, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

b. The recommended repair methods list shall be arranged in a columnar format and shall list all devices in the equipment data compliance booklet and state the guidance on recommended repair methods, either field repair, factory repair, or whole-item replacement.

c. The as-built equipment data booklet shall include the equipment compliance booklet and manufacturer supplied user manuals and information.

d. If the operation manual and the maintenance and repair manual are provided in a common volume, they shall be clearly differentiated and separately indexed.

1.7 RISK MANAGEMENT FRAMEWORK

The contractor shall obtain Risk Management Framework Certification for the Building Management System (BMS) per Section 01 91 10.01 29 CYBERSECURITY/RISK MANAGEMENT FRAMEWORK REQUIREMENTS.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two years' use shall include applications of equipment and materials under similar circumstances and of similar size. The two years' experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6,000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Automatic temperature controls shall be direct digital controls that will provide the required sequence of operation.

2.1.1 Risk Management Framework Equipment Certification

Furnish a certification packet that demonstrates and certifies that control systems are designed and tested in accordance with DoD Instruction 8500.01, DoD Instruction 8501.01, and as defined by Section 01 91 10.01 29 CYBERSECURITY/RISK MANAGEMENT FRAMEWORK REQUIREMENTS.

2.1.2 Electrical and Electronic Devices

Electrical, electronic, and electropneumatic devices not located within a DDC panel shall have a NEMA ICS 1 enclosure in accordance with NEMA 250 unless otherwise shown.

2.1.3 Ambient Temperature Limits

DDC panels shall have ambient condition ratings of 35 to 120 degrees F and 10 to 95 percent relative humidity, noncondensing. Devices installed outdoors shall operate within limit ratings of minus 35 to plus 150 degrees F. Instrumentation and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

2.2 TUBING

2.2.1 Plastic

Plastic tubing shall have barbed fittings and valves. Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

2.3 WIRING

2.3.1 Terminal Blocks

Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.3.2 Control Wiring for 24-Volt Circuits

Control wiring for 24-volt circuits shall be 18 AWG minimum, stranded copper and shall be rated for 300-volt service.

2.3.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG or thicker stranded copper and shall be rated for 600-volt service.

2.3.4 Instrumentation Cable

Instrumentation cable shall be 20 AWG, stranded copper, single- or multiple-twisted, and shall have a 300-volt insulation. Cables shall have overall cable insulation.

2.3.5 Transformers

Step down transformers shall be utilized where control equipment operates at lower than line circuit voltage. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Transformers shall be UL 1585 approved. Transformers shall be sized so that the connected load is no greater than 80% of the transformer rated capacity.

BMS contractor to provide 120VAC to 24VAC stepdown transformers as required for BMS control power. 120VAC power connections provided under Div. 26.

2.4 ACTUATORS

Actuators shall be pneumatic, electric or electronic as shown and shall be provided with mounting and connecting hardware. Electric or electronic actuators shall be used for variable air volume (VAV) air terminal units. Actuators shall fail to their spring-return positions on signal or power failure. Actuators shall have a visible position indicator. Actuators shall smoothly open or close the devices to which they are applied and shall have a full stroke response time of 90 seconds or less. Electric or electronic actuators operating in series shall have an auxiliary actuator driver. Electric or electronic actuators used in sequencing applications shall have an adjustable operating range and start point. Pneumatic actuators shall be rated for 25 psig operating pressure except for high-pressure cylinder-type actuators.

2.4.1 Valve Actuators

Valve actuators shall be selected to provide a minimum of 125 percent of the motive power necessary to operate the valve over its full range of operation.

2.4.2 Positive Positioners

Positive positioners are required for pneumatic actuators. Each positive positioner shall be a pneumatic relay with a mechanical feedback mechanism and an adjustable operating range and starting point.

2.5 AUTOMATIC CONTROL VALVES

2.5.1 General

a. Control valves shall be two-way or three-way type single seated globe type or ball valve type for two-position or modulating service as shown. Valves less than 1-1/2" shall meet ANSI Class IV leakage rating.

b. Valves used for chilled water shall be calibrated for 40% propylene glycol service at 51 degrees F average temperature while used for hot water shall be calibrated for 50% propylene glycol service at 120 degrees F average temperature.

c. Valve actuators shall be of electric type.

d. Control valve operators shall be sized to close against a differential pressure equal to the design pump head in normal operation.

e. Provide valves 2 inches and smaller with screwed end bronze or brass bodies. Provide valves 2-1/2 inches and larger with flanged ends, cast iron body and stainless steel trim.

f. For modulating service that require large valve size (above 6 inches), such as cooling tower temperature bypass, chiller head pressure ,etc. where proper control with globe type control valve cannot be achieved or the application is not economical butterfly valves are allowed. Valves used for hydronic service shall be rated for propylene glycol service.

2.5.2 Water Valves

a. Control valves shall provide reliable flow characteristics for modulating service.

b. Sizing Criteria (non-Pressure Independent):

1) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through the coil, 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.

2) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil, 5 psi maximum.

3) Differential pressure service: 70% of design flow and 50% of pump head.

4) Water valves shall fail normally open or closed, as scheduled on plans, or as required by sequences of operation.

c. Sizing Criteria (Pressure Independent):

1) Two-way modulating service: Two-way modulating service: Maximum flow shall be limited to the design flow of the coil. This GPM will be used to size the valve, not the traditional flow coefficient and pressure drop method.

2) The differential pressure range for effective pressure independent operation shall be 2.6 - 58 psi for ½" valves, in no instance shall the minimum effective pressure differential for effective pressure independent operation exceed 4 psi for valves under 2" line size.

d. Pressure Independent control Valves (PICV)

1) Valves shall be of globe-style bodies.

2) Valves shall contain a pressure independent regulator, a variable flow control, and an adjustable flow limiter.

3) The adjustable flow limiter shall indicate maximum GPM set points and allow field adjustment of the maximum allowable flow. The flow limiter shall allow the valve to retain the full range of flow control travel independent of the flow limit setting.

4) Valves shall have a linear flow characteristic.

5) The valves shall be provided with actuators by the same manufacturer factory installed.

6) Approved Manufacturer(s). Siemens

2.5.3 Steam Valves

a. Control valves shall be of linear flow characteristics for modulating service.

b. Sizing Criteria:

1) 15 psig or less; pressure drop 80% of inlet psig.

2) 16 to 50 psig; pressure drop 50% of inlet psig.

3) Over 50 psig; pressure drop as scheduled on plans.

a) Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:

b) Heating coils in air handlers: normally open.

c) Steam to hot water heat exchanger: normally closed.

d) Other applications: as required by sequences of operation.

2.5.4 Valve Specification for Distribution Valves

a. Flanged Valves, line size 2 ½" to 6"

1) Controlled Media Specific Items

a) Steam control valve shall be suitable for saturated steam to a maximum temperature of 337°F (170°C) and a maximum pressure of 100 psig (690 kPa). A Linear flow characteristic and stainless steel trim is recommended.

b) Water control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

c) Glycol Solutions control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 20°F (-7°C) and hot glycol/water solutions to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

2) General Construction Materials/Applicable

a) Standards Pressure Class 125 control valve bodies shall be constructed of gray cast iron according to ASTM A126B, and shall meet requirements of ANSI B16.1, pressure class ANSI 125.

b) Pressure Class 250 control valve bodies shall be constructed of gray cast iron according to ASTM A126B, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.

c) For Class 125 and Class 250 valve assemblies, flange dimensions shall be according to ANSI B16.1, and valve body flange-to-flange dimensions shall be according to ANSI/ISA S75.03.

d) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

e) The control valve shall have a linear flow characteristic, according to ANSI/ISA S75.11.

f) The control valve shall have a modified equal percentage flow characteristic.

g) The control valve shall have a minimum rangeability of 100:1.

h) Valve shall meet the requirements of seat leakage Class IV (0.01%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.

i) Chilled and Hot water valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings.

j) Steam valve stem packing shall be of a spring-loaded cartridge type and shall contain at least seven Teflon v-rings and one EPDM o-ring

k) Control valve seat shall be made of stainless steel according to UNS S30300 or ASTM A582 Type 303, and plug shall be made of bronze according to UNS C84400.

l) Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.
m) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A.

3) Service Parts

a) Chilled and Hot water valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings. The cartridge type packing shall be replaceable as a unit.

b) Steam valve stem packing shall be of a spring-loaded cartridge type and shall contain at least three Teflon v-rings and one EPDM o-ring.

c) The control plug and stem shall be replaceable as a unit.

b. Threaded Valves, line size ½" to 2"

1) Controlled Media Specific Items

a) The control valve shall be suitable for saturated steam to a maximum temperature of 337°F (170°C) and a maximum pressure of 100 psig (690 kPa). A Linear flow characteristic and stainless steel trim is recommended.

b) The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

c) The control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 20°F (-7°C) and hot glycol/water solutions to a maximum temperature of 250°F (120°C). A modified equal percentage flow characteristic is recommended. Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of cast bronze according to UNS C84400 or forged brass according to UNS C37700, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.

b) Threaded connection specifications shall be according to ANSI B2.1.

c) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

d) The control valve shall have a linear flow characteristic, according to ANSI/ISA S75.11.

e) The control valve shall have a modified equal percentage flow characteristic..

f) The control valve shall have a minimum rangeability of 100:1.

g) Valve shall meet the requirements of seat leakage Class IV(0.01%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.

h) Valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings.

i) Valve stem packing shall be of a spring-loaded cartridge type and shall contain at least three Teflon v-rings and one EPDM o-ring.

j) Control valve seat shall be made of bronze according to UNS C84400 or stainless steel according to UNS S30300 or ASTM A582 Type 303, and plug shall be made of bronze according to UNS C84400 and/or brass according to UNS C36000 or C37700.

k) Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.

l) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A.

3) Service Parts

a) Chilled and Hot water valve stem packing shall be of a cartridge type and shall contain at least two EPDM o-rings. The cartridge type packing shall be replaceable as a unit.

b) Steam valve stem packing shall be of a spring-loaded cartridge type and shall contain at least three Teflon v-rings and one EPDM o-ring.

c) The control plug and stem shall be replaceable as a unit.

2.5.5 Valve Specification for Terminal Unit Valve

a. Threaded Valves, line size ½" to 1"

1) Controlled Media Specific Items

a) The control valve shall be suitable for saturated steam to a maximum temperature of 250°F (120°C) and a maximum pressure of 15 psig (103.5 kPa). A linear flow characteristic and stainless steel trim is recommended.

b) The control valve shall be suitable for chilled water to a minimum of 32°F (0°C) and hot water to a maximum temperature of 250°F (120°C). Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

c) The control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 32°F (0°C) and hot glycol/water solutions to a maximum temperature of 250°F (120°C). Bronze or brass trim is recommended for operating differential pressures up to 25psi. Stainless steel trim is recommended for operating differential pressures up to 50psi.

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of cast bronze according to UNS C84400 or forged brass according to UNS C37700, and shall meet requirements of ANSI B16.1, pressure class ANSI 250.

b) Threaded connection specifications shall be according to ANSI B2.1.

c) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

d) The control valve shall have a modified equal percentage flow characteristic, according to ANSI/ISA S75.11.

e) The control valve shall have a minimum rangeability of 100:1 on valves with a Cv value greater than or equal to 1.0 and a minimum rangeability of 50:1 on valves with a Cv value less than 1.0.

f) Valve shall meet the requirements of seat leakage Class IV (0.01%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.

g) Chilled water, Hot water, and Steam valve stem packing shall contain at least two EPDM o-rings.

h) Control valve seat shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303 and plug shall be made of bronze according to UNS C84400 and/or brass according UNS C36000 or C37700.

i) Control valve seat and plug shall be made of stainless steel according to UNS S30300, or ASTM A582 Type 303.

j) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A

2.5.6 Valve Specification for Zone Valves

a. Threaded or Sweat Connection Valves, line size ½" to 1"

1) Controlled Media Specific Items

a) The control valve shall be suitable for chilled water to a minimum of 34°F (1°C) and hot water to a maximum temperature of 230°F (110°C).

b) The control valve shall be suitable for 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 34°F (1°C) and hot glycol/water solutions to a maximum temperature of 230°F (110°C).

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of forged brass and shall meet requirements of ANSI B16.1, pressure class ANSI 125.

b) Threaded connection specifications shall be according to ANSI B2.1.

c) Sweat connection specifications shall be according to ANSI B16.22.

d) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

e) The control valve shall have a linear flow characteristic, according to ANSI/ISA S75.11.

f) Valve shall meet the requirements of seat leakage Class III (0.1%) according to ANSI/FCI 70.2, with no more than 125% of nominal force necessary to balance fluid forces applied to valve stem.

g) Chilled and Hot water valve stem packing shall contain at least two EPDM o-rings.

h) Control valve seat and plug shall be made of brass according UNS C36000.

i) Valve stem shall be made of polished stainless steel according to ASTM A581/A or ASTM A582/A.

2.5.7 Valve Specification for characterized Ball Valves

a. Threaded Valves, line size ½" to 2"

1) Controlled Media Specific Items

a) The control valve shall be suitable for chilled water to a minimum of 35°F (2°C) and hot water to a maximum temperature of 250°F (121°C).

b) The control valve shall be suitable for up to 50% ethylene or propylene glycol solutions, chilled glycol/water solutions to a minimum of 35°F (2°C) and hot glycol/water solutions to a maximum temperature of 250°F (121°C).

2) General Construction Materials/Applicable Standards

a) Control valve bodies shall be constructed of forged brass according to ASTM B283 (CuZn39Pb2 or equivalent), and shall meet requirements of ANSI 250 and 600WOG pressure classes.

b) Inlets and outlets shall be clearly marked on the valve bodies.

c) Valve ball shall consist of nickel-plated brass, chrome-plated brass or stainless steel.

d) End connections shall be NPT internally threaded according to ANSI B1.20.1.

e) The control valve flow rate (Cv) shall meet the requirements of ANSI/ISA S75.02.

f) The control valve shall have an equal percentage flow characteristic, according to ANSI/ISA S75.11. A glass filled PTFE V port insert shall establish the flow coefficient of the valve. The V port shall be retained by the valve body itself, not requiring additional retainers components. Manufacturer may also provide a glass filled polymer ball insert, as an integral part of the ball, for modulating flow applications. Flow coefficient adapters installed after final assembly of the valve shall not be allowed.

g) Valve shall meet the requirements of ANSI Class IV (0.01% of rated Cv) seat leakage, or better, according to ANSI/FCI 70.2, at the specified close-off pressure.

h) Chilled and Hot water valve shall have a blow-out proof stem with two EPDM (peroxide cured) O-rings. External stem retainers will not be allowed.

i) Valve stem shall be made of brass or stainless steel.

j) Valve shall have the ability to be manually operated in the event of a power failure.

2.5.8 Automatic Control Valve Actuators

a. Electronic Valve Actuators

1) Applicable Standards

a) 24V valve actuator shall be identified as a Class 2 operating device, according to NEC, Article 725.

b) 120V valve actuator shall be identified as a Class 1 operating device, according to NEC, Article 725.

c) The valve actuator shall be tested and listed by Underwriters Laboratories according to UL873, and shall bear the UL and cUL approval symbols.

d) The valve actuator shall be designed and tested to NEMA 1 standards, according to NEMA 250.

2) Direct Coupled

a) The control valve actuator shall be directly coupled to the valve, with no intermediary linkage kit required, to facilitate repair and/or replacement.

b) The control valve actuator shall be equipped with a manual override feature, allowing operation of the control valve upon loss of control power or signal, without the aid of a separate tool or auxiliary power supply.

3) Fail Safe operation

a) Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by means of a mechanical spring.
b) Upon power failure or loss of control signal, the valve actuator shall return to a fail-safe operating position by self-contained electronic means.
c) Upon power failure, the valve actuator shall maintain its last controlled position (fail in place).

4) Visual position indication

a) The valve actuator shall provide indication of valve stem position, clearly visible from a distance of 15ft. (4.5m).

5) Ball Valve Actuators Torque Requirement

a) The control valve actuator shall provide minimum torque required for full valve shutoff position.

2.6 INSTRUMENTATION

2.6.1 Measurements

Transmitters shall be calibrated to provide the following measurements, over the indicated ranges:

a. Conditioned space temperature, from 55 to 85 degrees F.

b. Duct temperature, from 40 to 140 degrees F.

c. High-temperature hot-water temperature, from 200 to 500 degrees F.

d. Chilled-water temperature, from 30 to 100 degrees F.

e. Dual-temperature water, from 30 to 240 degrees F.

f. Heating hot-water temperature, from 50 to 250 degrees F.

g. Outside-air temperature, from minus 58 to 122 degrees F.

h. Relative humidity, 0 to 100 percent for space and duct high-limit applications.

i. Differential pressure for VAV supply-duct static pressure from 0 to 2.0 inches water gauge.

j. Pitot-tube air-flow measurement station and transmitter, from 0 to 0.1 inch water gauge for flow velocities of 700 to 1200 fpm, 0 to 0.25 inch water gauge for velocities of 700 to 1800 fpm, or 0 to 0.5 inch water gauge for velocities of 700 to 2500 fpm.

k. Electronic air-flow measurement station and transmitter, from 125 to 2500 fpm.

2.6.2 Temperature Sensors

1. Provide the following instrumentation as required by the monitoring, control and optimization functions. All temperature sensors shall use platinum RTD elements only, nickel or silicon are not acceptable.

2. Room Temperature (where wired to Building Controllers. See Application Specific Controller Section for Room Temperature Sensors wired to ASCs):

a. Temperature monitoring range +40/+90°F or +40/+240°F
b. Installation adjustments none required
c. Calibration adjustments none required
d. Factory calibration point 32°F
e. Accuracy at calibration point +/- 0.7°F

3. Liquid Immersion Temperature

a. Temperature monitoring range +30/+250°F, +20/+70°F,+32/+212°F, or +40/+240°F
b. Installation adjustment none required
c. Calibration adjustments none required
d. Factory calibration point 32°F
e. Accuracy at calibration point +/- 0.54°F

4. Duct (Single Point) Temperature

a. Temperature monitoring range +20/+120°F,+30/+250°F, or +40/+240°F
b. Installation adjustments none required
c. Calibration adjustments none required
d. Factory calibration point 70°F
e. Accuracy at calibration point +/- 0.54°F

5. Duct (Averaging) Temperature

a.	Temperature monitoring range	+20/+120°F or +40/+240°F
b.	Installation adjustments	none required
c.	Calibration adjustments	none required
d.	Factory calibration point	32°F
e.	Accuracy at calibration point	+/- 0.54°F

6. Outside Air Temperature

a.	Temperature monitoring range	-58/+122°F
b.	Output signal	4-20 mA
c.	Installation adjustments	none required
d.	Calibration adjustments	none required
e.	Factory calibration point	32°F
f.	Accuracy at calibration point	+/- 0.54°F

2.6.3 Relative Humidity Instruments

A relative-humidity instrument for indoor application shall have a measurement range from 0 to 100 percent relative-humidity and be rated for operation at ambient air temperatures within the range of 25 to 130 degrees F. It shall be capable of being exposed to a condensing air stream (100 percent RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The instrument shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Instruments used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted instruments shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage. The instrument (sensing element and transmitter) shall be a two-wire, loop-powered device and shall have an accuracy of plus or minus three percent of full scale within the range of 20 to 80 percent relative humidity. The instrument shall have a typical long-term stability of 1 percent or less drift per year. The transmitter shall convert the sensing element's output to a linear 4-20 mAdc output signal in proportion to the measured relative-humidity value. The transmitter shall include offset and span adjustments.

2.6.4 Electronic Airflow Measurement Stations and Transmitters

2.6.4.1 Stations

Each station shall consist of an array of velocity sensing elements. The velocity sensing elements shall be of the RTD or thermistor type, producing a temperature compensated output. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published application data of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 0.08 inch water gauge at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflows of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus three percent over a range of 125 to 2,500 fpm. In outside air measurement or in low-temperature air delivery applications, the station shall be certified by the manufacturer to be accurate as specified over a temperature range of minus 20 to plus 120 degrees F.

2.6.4.2 Transmitters

Each transmitter shall produce a linear, 4-to-20 mAdc, output corresponding to the required velocity pressure measurement. The transmitter shall be a two-wire, loop powered device. The output error of the transmitter shall not exceed 0.5 percent of the calibrated measurement.

2.6.5 Pitot Tube Airflow Measurement Stations and Transmitters

2.6.5.1 Stations

Each station shall contain an array of velocity sensing elements. The velocity sensing elements shall be of the multiple pitot tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the station manufacturer. The resistance to air flow through the airflow measurement station shall not exceed 0.08 inch water gauge at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflows of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus three percent over a range of 500 to 2,500 fpm. This device will not be used if the required velocity measurement is below 700 fpm or for outside airflow measurements.

2.6.5.2 Transmitters

Each transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required velocity pressure measurement. Each transmitter shall have a low range differential pressure sensing element. The transmitter shall be a two-wire, loop powered device. Sensing element accuracy shall be plus or minus one percent of full scale, and overall transmitter accuracy shall be plus or minus 0.25 percent of the calibrated measurement.

2.6.6 Differential Pressure Instruments

The instrument shall be a pressure transmitter with an integral sensing element. The instrument over pressure rating shall be 300 percent of the operating pressure. The sensor/transmitter assembly accuracy shall be plus or minus two percent of full scale. The transmitter shall be a two-wire, loop-powered device. The transmitter shall produce a linear 4-to-20 mAdc output corresponding to the required pressure measurement.

2.6.7 Thermowells

Thermowells shall be stainless steel. Inside diameter and insertion length shall be as required for the application.

2.6.8 Sunshields

Sunshields for outside air temperature sensing elements shall prevent the sun from directly striking the temperature sensing elements. The sunshields shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings.

2.6.9 Hydronic BTU Meters

The BTU meter is to be supplied with wall mount hardware and be capable of being installed remote from the flow meter. The BTU meter must include an LCD display for local indication of energy rate and for display of parameters and settings during configuration. Each BTU meter must be factory configured for its specific application and be completely field configurable by the user via a front panel keypad (no special interface device or computer required). The unit must output Energy Rate, Energy Total, Flow Rate, Supply Temperature, and Return Temperature. An integral transmitter is to provide a linear analog or configurable pulse output signal representing the energy rate; and the signal must be compatible with building automation system DDC Hardware to which the output is connected.

Flow meter used for chilled water shall be calibrated for 40% propylene glycol service while used for hot water shall be calibrated for 50% propylene glycol service.

2.6.10 Kilowatt Meter

Refer to Electrical Specification Section 26 11 14.01 10.

2.6.11 Hydrogen Gas Detector and Panel

The gas detector shall detect mixture of air and combustible gas, such as hydrogen, at concentrations below the lower concentration limit before an explosive atmosphere is created. The gas detector shall be suitable for use in the Battery Room. The gas detector shall have two response stages related to the gas concentration, and these shall be signaled in two different ways by the response indicator. The detector shall be capable of field adjustment. The hydrogen gas detector shall be located per manufacturer's recommendations.

The hydrogen gas detector panel shall be designed for gas detection system and shall conform to UL 864. The control unit shall provide the detectors with the necessary operating voltages, process the signals received from the detectors, signal the operating condition of the systems visually and audibly, sound alarm in the building, and transmit alarm condition to the fire alarm control panel. The contractor shall provide addressable interface modules, wiring, conduit, and tie-ins between the HDP and the fire alarm control panel. The detection system shall be two stage: Lower concentration Limit (LCL) alarm and higher concentration limit (HCL) alarm shall be field-adjustable. Actuation of LCL alarm shall sound alarm horn and flashing light outside battery room and transmit alarm signal to FACP, and DDC control system. Actuation of HCL alarm shall actuate alarm throughout the building. The control panel shall be steel cabinet with door and lock. All control modules shall be enclosed in the panel. The front panel shall give a clear view of all operating and signaling elements on the modules. The control unit shall be provided with a test switch for testing of the gas detection system. An emergency battery shall provide emergency power if the main supply fails. The batteries shall have ample capacity with primary power disconnected to operate the fire alarm system for a period of 48 hours. Following this period of operation via batteries, the batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a period of five minutes. Batteries shall be sized to deliver 50 percent more ampere/hours based on a 48-hour discharged rate than required for the calculated capacities.

Faults arising in detectors, detector wiring, control unit, operation of system disconnect or system test mode shall actuate a common trouble alarm and visual indication on the control panel. This trouble alarm condition shall be transmitted to the fire alarm control panel.

2.6.12 Carbon Dioxide Sensor and Transmitter

Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output, for wall mounting.

2.7 THERMOSTATS

2.7.1 Line-Voltage Space Thermostat

Line-voltage thermostats shall be bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating. The thermostat cover shall provide exposed setpoint adjustment knob, or concealed adjustment under blacnk faceplate (optional). The thermostat shall operate within the 55°F to 85°F setpoint range, with 2°F maximum differential.

2.7.2 Low-temperature Safety Thermostat

Low-limit air stream thermostats shall be UL listed, vapor pressure type, with a sensing element of 20 ft. minimum length. Element shall respond to the lowest temperature sensed by any 1 ft. section. The low-limit thermostat shall be automatic reset, SPDT type.

2.7.3 Aquastat

Strap-on type thermostats shall be provided for low or high temperature limit service on hot water or steam condensate pipes. The thermostats shall be UL Listed, with a liquid-filled bulb type sensing element and capillary tubing. The thermostat shall operate within the 20°F to 120°F, or 100°F to 240°F, setpoint range, with an adjustable 6°F differential.

The low-limit thermostat shall be automatic reset, snap acting SPDT type with concealed setpoint adjustment.

2.8 FLOAT SWITCH

Direct acting float switch consisting of a normally-open mercury switch enclosed in a float. Use pipe mounted float assembly. Use float molded of rigid high-density polyurethane foam, color-coded and coated with a durable, water and corrosion-resistant jacket of clear urethane. Provide connecting cable and support pole in accordance with manufacturers recommendations. Provide a cast aluminum NEMA Type 4 junction box with submersible connectors to connect float assembly. Use box with a gasketed cover with tapped float fitting and conduit entrance pipe threaded opening. Mount float at fixed elevations as shown. Use float designed to tilt and operate their switches causing indication to the control system, when the liquid level being sensed rises or falls past the float.

2.9 PRESSURE SWITCHES AND SOLENOID VALVES

2.9.1 Water Differential Pressure Switches

a. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.

b. The differential switches shall meet the following requirements:

1)	Range	8 to 70 psi
2)	Differential	3 psi
3)	Maximum differential pressure	200 psi
4)	Maximum pressure	325 psi

2.9.2 Air Differential-Pressure Switch

a. Differential pressure switches shall be diaphragm type with adjustable setpoint. Switches shall be SPDT. Switch pressure range shall be suited for application (e.g., filter 0-2.0", fan status 0-5.0", etc.).

2.9.3 Pneumatic Electric (PE) Switches

Each switch shall have an adjustable setpoint range of 3 to 20 psig with a switching differential adjustable from 2 to 5 psig. The switch action shall be SPDT.

2.9.4 Solenoid-Operated Pneumatic (EP) Valves

Each valve shall have three-port operation: common, normally open, and normally closed. Each valve shall have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection shall be a 3/8 inch NPT threaded connection. Valves shall be rated for 50 psig when used in a control system that operates at 25 psig or less, or 150 psig when used in a control system that operates in the range of 25 to 100 psig.

2.10 CONTROL DEVICES AND ACCESSORIES

2.10.1 Relays

Control relay contacts shall have utilization category and ratings selected for the application, enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less.

2.10.2 Current Sensing Relays

Current sensing relays shall provide a normally-open contact rated at a minimum of 30 volts peak and 0.4 ampere. There shall be a single hole for passage of current carrying conductors. The devices shall be sized for operation at 50 percent rated current based on the connected load. Voltage isolation shall be a minimum of 600 volts.

2.11 DIRECT DIGITAL CONTROL (DDC) HARDWARE

All functions, constraints, data base parameters, operator developed programs and any other data shall be downloadable from a portable workstation/tester or the central workstation/tester to network control panels, RIU's, universal programmable controllers, and unitary controllers. Download shall be accomplished through both the primary network and the local DDC portable workstation/tester port.

2.11.1 Building DDC Controller

A. Approved Building Controllers (no substitutions).

1. Siemens Industry, Inc. - APOGEE PXC Compact Controllers, PXC Modular Controllers, using Siemens P2 communication protocol.

B. Building Controllers shall be 32-bit, multi-tasking, multi-user, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

C. Each Building Controller shall have sufficient memory, a minimum of 24 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications. The system supplied with 20% spare processor capacity, installed I/O capacity and cabient space for expansion. BMS server shall be capable of supporting future expansion to a maximum of 10,000 total physical I/O points. the required hardware hardware for addition of I/O cabinets, supervisory controllers, field controllers, and workstations in future FY19 and Radar Prime buildings will be designed and provided under future building design package.

D. Provide Universal I/O capability, including software configurable universal inputs and universal outputs.

E. Each Building Controller shall support a minimum of one directly connected Secondary Network.

F. Building Controller shall have an integral real-time clock.

G. Each Building Controller shall support firmware upgrades without the need to change hardware.

H. Each Building Controller shall support:

1. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.

2. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

I. Spare Point Capacity.

1. Each Building Controller shall have a minimum of 20 percent spare point capacity.

2. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.

3. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:

a. Expansion modules
b. Sensor/actuator
c. Field wiring/tubing

4. Spare point capacity is evaluated with respect to this construction package. Under subsequent other FY17 Construction

Packages, future FY19 and Radar Primer design/construction packages, spare capacity shall be provided for with respect to those projects as part of those project requirements.

J. Serial Communication. Building Controllers shall provide at least two EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.

K. I/O Status and Indication. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.

L. Shall provide I/O modules with LCD's capable of displaying information faults including but not limited to open circuit, short circuit, unreliable input signal, signal under range, and signal over range via informative symbols.

M. Self Diagnostics. Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

N. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 30 days.

Provide local UPS with back-up battery at each DDC controller.

O. Environment.

1. Controller hardware shall be suitable for the anticipated ambient conditions.

2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

3. Controllers used in conditioned space shall be mounted in **AM#9...NEMA-1...AM#9** enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

P. Immunity to power and noise.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

a. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V

b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact

c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500V signal, 1 kV power

d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)

3. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:

a. IEEE Standard 587 1980

b. UL 864 Supply Line Transients

c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.11.1.1 Duplex Outlet

A single phase, 120 Vac electrical service outlet for use with test equipment shall be furnished either inside or within 6 feet of the Building Controller panel enclosure.

2.11.1.2 Locking Enclosures

Locking type mounting cabinets with common keying shall be furnished for each Building Controller.

2.11.2 Application Specific Controller (ASC)

A. General

1. Approved Building Controllers (no substitutions).

a. Siemens Industry, Inc. - Siemens APOGEE Controllers, TEC using P1 communication protocol.

2. Provide for control of each applicable piece of equipment, such as terminal units, temperature zone controllers, and etc..

3. Each Building Controller shall be able to communicate with application specific controllers (ASCs) over the Secondary Network to control terminal equipment only.

4. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

5. Each ASC shall include all point inputs and outputs necessary to perform the specified control sequences. The ASC shall accept input and provide output signals that comply with industry standards. Outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.

6. Space Temperature Sensors.

a. Wired temperature sensor specifications. The sensing element for the space temperature sensor must be IC-based and provide the following.

1) Digitally communicating with the Application Specific Controller.

2) Mountable to and fully covering a 2 x 4 electrical junction box without the need for an adapter wall plate.

3) IC Element Accuracy: +/- 0.9°F

4) Operating Range: 55 to 95°F

5) Setpoint Adjustment Range: User limiting, selectable range between 55 and 95°F

6) Display of temperature setpoint with numerical temperature values

7) Calibration: Single point, field adjustable at the space sensor to +/- 5°F

8) Installation: Up to 100 ft. from controller

9) Auxiliary Communications Port: included

10) Local OLED Temperature Display (OPTIONAL)

11) Display of Temperature to one decimal place (OPTIONAL)

12) Temperature Setpoint Adjustment (OPTIONAL) included

13) Occupancy Override Function (OPTIONAL)included

b. Setpoint Modes:

1) Independent Heating, Cooling

2) Night Setback-Heating

3) Night Setback-Cooling

c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

d. Setpoint Adjustment Dial (OPTIONAL). The setpoint adjustment function dial shall allow for modification of the temperature by the building operators. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.

e. Override Switch (OPTIONAL). An override button shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

7. Space Combination Temperature and Humidity Sensors (WHERE APPLICABLE). Each controller performing space temperature control shall be provided with a matching room temperature sensor, which also includes the ability to measure humidity for either monitoring or control purposes. The combination temperature and humidity sensors shall have the same appearance as the space temperature sensors. Humidity elements shall measure relative humidity with a +/- 2% accuracy over the range of 10 to 90% relative humidity. Humidity element shall be an IC (integrated circuit) sensing element. Humidity sensing elements shall be removable and field replaceable if needed.

8. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

9. Control Algorithms. The controller shall receive its real-time data from the Building Controller time clock to ensure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

10. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

11. Programmability. Application Specific Controllers shall be programmable, using software provided by the BMS manufacturer. Software shall be field-installable on any standard laptop or Portable Operator's Terminal. Program language shall be text-based and allow up to 200 lines of code for programming. Programming shall allow for changing sequence of operation, commanding and releasing points, additional monitoring, and command priority management within the Application Specific Controller.

12. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and ensuring against drift over time.

a. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary.

b. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 cfm air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

c. Calibration shall be accomplished by zeroing out the pressure sensor and holding damper at last known position until calibration is complete. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

13. Memory.

a. Provide each ASC with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

b. Upon replacement, new ASCs shall recover control function and site specific defaults automatically and resume normal operation.

14. Power Supply. The ASCs shall be powered from a 24 Vac source and shall function normally under an operating range of 18 to 28 Vac, allowing for power source fluctuations and voltage drops. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 Vac power to the terminal units by utilizing:

a. The existing line voltage power trunk and installing separate isolation transformers for each controller.

b. Dedicated line voltage power source and isolation transformers at a central location and installing 24 Vac power trunk to supply multiple ASCs in the area.

15. Environment. The controllers shall function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 95% rh (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

16. Immunity to noise. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

17. Manufacturer Installed Controls (WHERE APPLICABLE).

a. BMS manufacturer shall furnish ASC and actuator for factory mounting to equipment manufacturer.

b. Cost of factory mounting shall be borne by equipment manufacturer.

c. For VAV terminals, equipment manufacturer shall provide and install flow-cross sensor, 24 Vac transformer, controls enclosure, fan relay, SCR and factory install, wire and tube ASC controller and actuator.

d. Fan powered VAV terminals shall be equipped with a fan speed controller and relay to change summer and winter speed setpoint.

2.11.3 I/O Functions

2.11.3.1 Input/Output Interface

A. Hardwired inputs and outputs may tie into the system through building or application specific controllers.

B. Building Controllers shall support modular, "hot-swappable" I/O so that the electronics of a small portion of the I/O can be replaced without effecting the power or communication for the other points.

C. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.

D. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.

E. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to ten (10) pulses per second for pulse accumulation.

F. Analog inputs shall allow the monitoring of low-voltage (0 to 10 Vdc), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with-and field configurable to-commonly available sensing devices.

G. 24 Vdc shall be available next to the point signal for powering the output device.

H. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

I. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 Vdc or 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

J. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.11.4 Workstations and Software

A. Siemens APOGEE Insight front-end graphical user interface, no substitutions.

B. Workstation hardware:

1. Personal computer operator workstations shall be provided for command entry, information management, system monitor, alarm management and database management functions. All real-time control functions shall be resident in the Building Controllers to facilitate greater distribution, fault tolerance and reliability of the building automation control.

a. Provide workstation(s) of equal capability as located on plans.

b. Workstation shall consist of a personal computer with minimum 8 GB RAM, hard drive with 320 GB available space, video card with 2.4 GHz processor capable of supporting a minimum of 1280 × 1024 resolution with a minimum of 32-bit color, CD-RW (DVD-RW Preferred), and DVD-ROM Drive, mouse and 101-key enhanced keyboard. Personal computer shall be a Windows 2008 or comparable operating system and shall include a minimum quad core processor.

c. The PC monitor shall be of flat panel type and shall support a minimum display resolution of no less than 1280 × 1024 pixels. The display shall have a minimum of 24-inch visible area in diagonal measurement. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.

d. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

C. Server hardware:

1. The server hardware shall be of equal or better capability as that of workstation and shall be equipped as follows.

a. Locate server as located on plans.

b. Provide a minimum 16 GB RAM, with two hard drives of 500 GB available space each, with a RAID controller, a video card with 2.4 GHz processor capable of supporting a minimum of 1280 × 1024 resolution with a minimum of 32-bit color, CD-RW (DVD-RW Preferred), and DVD-ROM Drive, mouse and 101-key enhanced keyboard. Server shall be a Windows 2008 or comparable operating system, and shall include a minimum quad core processor or better.

c. Provide a monitor of flat panel type and shall support a minimum display resolution of no less than 1280 × 1024 pixels. The display shall have a minimum of 24-inch visible area in diagonal measurement. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.

d. Provide dual servers. Each server to be configured for, and have full capacity to handle entire system for full redundancy.

e. Server hardware and software shall be provided to accommodate a minimum of 10,000 points, including 20% spare capacity.

D. Operator Interface Software:

1. Basic Interface Description

a. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with and share data between Ethernet-connected building level networks.

b. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a "drag and drop" approach to inter-application navigation.

c. The navigation shall be user friendly by utilizing "forward & back" capability between screens and embedded hyperlinks to open graphics, documents, drawings, etc.

d. Selection of applications within the operator interface software shall be via a graphical toolbar menu-the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.

e. The graphical toolbar menu shall have the option of adding additional user definable buttons that can launch local or network programs, files, folders on Internet/Intranet addresses external to the BMS software.

f. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software shall run on a Windows 2008, or comparable 32/64-bit operating system. System database parameters shall be stored within an object-oriented database. Standard Windows applications shall run simultaneously with the BMS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.

g. The software shall provide, as a minimum, the following functionality:

1) Real-time graphical viewing and control of the BMS environment.

2) Reporting of both real time and historical information.

3) Scheduling and override of building operations.

4) Collection and analysis of historical data.

5) Point database editing, storage and downloading of controller databases.

6) Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.

7) Alarm reporting, routing, messaging, and acknowledgment.

8) "Collapsible tree" dynamic system architecture diagram application:

a) Showing the real-time status and definition details of all workstations and devices on a management level network.

b) Showing the real-time status and definition details of all Building Controllers at the Primary Network.

c) Showing the definition details of all application specific controllers.

9) Definition and construction of dynamic color graphic displays.

10) Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.

11) On-screen access to User Documentation, via online help or PDF-format electronic file.

12) Automatic database backup at the operator interface for database changes initiated at Building Controllers.

13) Display dynamic trend data graphical plot.

a) Must be able to run multiple plots simultaneously.

b) Each plot must be capable of supporting 10 pts/plot minimum.

c) Must be able to command points directly off dynamic trend plot application.

d) Must be able to plot both real-time and historical trend data.

14) Program editing

15) Report output shall have the option to be sent to an email address or group of email addresses.

16) Transfer trend data to third-party spreadsheet software

a) Scheduling reports

b) Operator Activity Log

c) Capable of communicating via OPC Server

d) Capable of communicating via BACnet client and server

h. Enhanced Functionality:

1) Provide functionality so that any of the following may be performed simultaneously online, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the trend graph application to initiate a dynamic trend on the desired point):

a) Dynamic color graphics application

b) Alarm management application

c) Scheduling application

d) Trend graph/data plotter application

e) System architecture application

f) Control Program and Point database editing applications

g) Reporting applications

2) Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

i. Security: Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application.

j. Each BMS workstation user account shall use a Windows Operating System user account as a foundation. BAS System administrator shall be able to add users to the BMS system by pulling in accounts from the Active Directory. Users will use the same Login ID/Password combination as to log into the corporate network.

k. The operator interface software shall also include an application to track the actions of each individual operator, such as alarm acknowledgement, point commanding, schedule overriding, database editing, and logon/logoff. The application shall list each of the actions in a tabular format, and shall have sorting capabilities based on parameters such as ascending or descending time of the action, or name of the object on which the action was performed. The application shall also allow querying based on object name, operator, action, or time range.

l. Dynamic Color Graphics application shall include the following:

1) Must include graphic editing and modifying capabilities.

2) All necessary tools and procedures for the user to create their own graphics

3) A library of standard control application graphics and symbols must be included.

4) Must be able to command points directly off graphics application.

5) Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks.

6) Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure.

7) Graphics viewing shall include zoom capabilities.

8) Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.

9) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet Web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.

10) Ability to create dashboard views that graphically display system and/ or energy performance. Dashboards will consist of gauges and charts.

m. Reports shall be generated on demand or via pre-defined schedule, and directed the computer monitor, printers, file or email address. As a minimum, the system shall allow the user to easily obtain the following types of reports:

1) A general listing of all or selected points in the network

2) List of all points currently in alarm

3) List of all points currently in override status

4) List of all disabled points

5) List of all points currently locked out

6) List of user accounts and access levels

7) List all weekly schedules and events

8) List of holiday programming

9) List of control limits and deadbands

10) Custom reports from third-party software

11) System diagnostic reports including, list of Building panels online and communicating, status of all Building terminal unit device points

12) List of programs

13) List of point definitions

14) List of logical point groups

15) List of alarm strategy definitions

16) List of Building Control panels

17) Point totalization report

18) Point Trend data listings

19) Initial Values report

20) User activity report

n. Scheduling and override

1) Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation and in the Building Controller to ensure time equipment scheduling when PC is offline, PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:

a) Daily, Weekly, and Monthly schedules

b) Ability to combine multiple points into a logical grouping (Zone) for ease of scheduling (e.g., Building 1 lights)

c) Ability to combine multiple groups of points into a common collection (Event) for scheduling (e.g., Building 1 and Parking Lot A lights)

d) Schedule predefined reports that can be sent to a printer, hard drive location, or emailed.

e) Ability to schedule for a minimum of up to ten (10) years in advance.

2) Additionally, the scheduling application shall:

a) Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report).

b) Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report).

c) Provide searching capabilities of schedules based on name - with wildcarding options.

o. Collection and Analysis of Historical Data

1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. At a minimum the BMS shall trend every 15 minutes (initial setting) for each point related to temperature, humidity, pressure, flow, variable speed drive, and control valve position, except for unit heaters and fin tube radiant heaters. Any system point may be trended automatically at time-based intervals or change of value, both of which shall be user-definable. Trend data shall be collected and stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of equipment. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

2) Panels shall have a trending level above which the data will be automatically uploaded to the BMS server to prevent overwriting the data in the field panel. The trending level will be user defined in % of available space (e.g., automatically upload when the trend buffer is at 75% of allocated space)

3) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred online to Microsoft Excel.

4) Provide additional functionality that allows the user to view real-time trend data on trend graphical plot displays. A minimum of ten points may be plotted, of either real-time or historical data. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of ten (10) dynamic graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point. Operator shall be able to zoom in on a specific time range within a plot. The dynamic trend plotting application shall support the following types of graphs, with option to graph in 3D: line graph, area graph, curve graph, area-curve graph, step graph, and scatter graph. Each graph may be customized by the user, for graph type, graph text, titles, line styles and weight,

colors, and configurable x- and y-axes.

5) Provide additional functionality that allows the user to display trend data for points from a graphic, alarm status screen, or a displayed point log report.

p. Dynamic Color Graphic Displays

1) Capability to create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including, but not limited to, air handling units, chilled water systems, hot water boiler systems, and room level terminal units.

2) The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.

3) Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

a) Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the operator interface software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed.

b) Sizable analog bars shall be available to monitor and control analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.

c) Ability to add custom gauges and charts to graphic pages. A library will be provided that contains at least the following: angular gauges, bulbs, thermometers, cylinders, linear gauges, 2D charts, 3D charts, pie charts, and column charts.

d) Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

e) Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.

f) State text for digital points can be user-defined up to eight characters.

g) Provide the user the ability to display trend data from the graphic screen through right click feature selection.

4) Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.

5) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet Web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.

6) The Windows environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

7) Off the shelf graphic software shall be provided to allow the user to add, modify or delete system graphic background displays.

8) A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.

9) The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.

10) The graphic application shall provide a tool be able to change full or partial point names on a graphic.

q. System Configuration & Definition

1) A "Collapsible tree," dynamic system architecture diagram/display application of the site-specific BMS architecture showing status of controllers, PC workstations and networks shall be provided. This application shall include the ability to add and configure workstations, Building Controllers, as well as third-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing third-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration and diagnostics connections to Building Controllers.

2) Network wide control strategies shall not be restricted to a single Building Controller, but shall be able to include data from any and all other network panels to allow the development of

Global control strategies.

3) Provide automatic backup and restore of all Building Controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is online without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Building Controller. Changes made at the user-interface of Building Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

4) System configuration, programming, editing, graphics generation shall be performed online.

5) User shall be able to edit point configuration online within a dedicated editor application that is part of the operator interface software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database.

6) The point editor shall have the capability to assign "informational text" to points as necessary to provide critical information about the equipment.

7) The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the Building Controllers.

8) The operator interface software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Point definition parameters, Alarm management definitions and Trend definitions.

9) Control program configuration shall be available to the user within a dedicated control program editor application included in the operator interface software. The editor shall allow for creation, modification and deletion of control programs. The editor shall include a programming assistance feature that interactively guides the user through parameters required to generate a control program. The editor shall also include the ability to automatically compile the program to ensure its compatibility with the Building Controllers. The editor shall provide the option for editing the control programs in an online or offline mode, and also the ability to selectively enable or disable the live program execution within the Building Controllers. Additional compiler checks shall be built into the program editor which assists in the verification of valid GOTO statements. The additional compiler check shall also verify if each point in the program was defined in another panel.

10) Users shall have the ability to view the program(s) that is/are currently running in a Building Controller. The display shall mark the program lines with the following: disabled, comment, unresolved, and trace bits.

r. Alarm Management

1) Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.

2) Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time and date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.

3) Alarm Display shall have the ability to list and sort the alarms based on alarm status, point name, ascending or descending alarm time.

4) Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.

5) Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm.

6) Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the option to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs. The system shall have the ability to modify the priority text based on operator preference.

7) Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BMS system management.

s. GPS time server

A GPS time server with network time protocol, connected to the BMS network to provide time synchronization for the historical data collection.

E. Historical Data Historian

1. System must provide a means to gather, archive and retrieve trend, alarm, and operator\ system activity records. Archived information shall be available for the life of the system for all points.

2. Historian may reside on the same physical server as the BMS software or on a separate computer. The data historian shall seamlessly integrate to the BMS software without the need for a third-party

application.

3. Historian must have five (5) simultaneous user licenses.

4. Users will use the same Login ID/Password combination as to log into the corporate network to access the software.

5. Historian shall have the ability to retrieve data from the BMS database for any available time period. A loss of communication between the historian and the BMS server will not result in data loss; the historian will have the ability to automatically collect data after the communications is restored.

6. System must allow archival to and from a corporate mass storage device.

7. Historian shall homogeneously combined historical data from multiple collection intervals for a given point (e.g., 15 minutes and change of value trends shall be blended into a common view).

8. The system must provide statistical formula capability and trend analysis graphical tools. The following shall be support:

a. Mean Kinetic Temperature (MKT) calculation on an array of data values.
b. Standard Deviation value determination of on an array of data values.
c. Average value determination of on an array of data values.
d. Minimum value determination of on an array of data values.
e. Maximum value determination of on an array of data values.
f. Sum of value an array of data values.
g. Delta value determination of on an array of data values.

9. Capability to create formulas using the trend data of BMS points. The following formulas must be supported: +, -, *, /, ABS (Absolute Value), COS (Cosine), COT (Cotangent), EXP (Exponential value), LOG, LOG10, PI, Power, Round, SIN, SQRT, and TAN (Tangent).

10. Historian shall have the ability to calculate Mean Kinetic Temperature (MKT) using the calculation formula from the USP.

11. Historian shall have a reporting package capable of displaying the following charts: Bar, Scatter (single and dual Y), Histogram, and Pie.

12. System shall be able to perform exception reporting (e.g., show all values below or above a certain value).

13. System shall be able to perform advanced analysis of BMS alarms to include the following information:

a. Number of alarms for a given period
b. Detailed alarm information; initial alarm, alarm cleared, duration, and highest level achieved during alarm

14. Statistical information: longest alarm duration, average duration, and total duration. System shall be able to compare to ranges of values for a given point in a scatter chart (e.g., energy usage for this month and the same period last year).

15. System shall have the ability to report on green house gases based on energy consumption data.

16. Historian reporting package shall allow the user to create custom design reports that can be printed, scheduled to run at a future time, saved to file, and/ or emailed.

17. Historian will have a schedule functionality that allows the user to schedule when reports run and where the output is directed (printer, file, or email).

2.12 DDC Software

2.12.1 DDC General Conditions

The Contractor shall provide software required to achieve the sequences of operation, parameters, constraints, and interlocks shown. Application software shall be resident in the DDC in addition to any other required software. In the event of a DDC failure, the controlled equipment shall continue to function in the failure mode shown.

Contractor shall produce graphical user interface screens depicting systems controlled or monitored, with every physical point being represented on at least one system/graphics screen.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION CRITERIA

3.1.1 Building Management System

The Building Management System shall be completely installed and ready for operation. Penetrations through and mounting holes in the building exterior shall be made watertight. The Building Management System installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.2 Software Installation

Software shall be loaded for an operational system, including databases for all points, operational parameters, and system, command, and application software. The Contractor shall provide original and backup copies of source, excluding the general purpose operating systems and utility programs furnished by computer manufacturers and the non-job-specific proprietary code furnished by the system manufacturer, and object modules for software on each type of media utilized, within 30 days of formal Government acceptance. In addition, an electronic copy of the database for each DDC panel shall be provided.

3.1.3 Device Mounting Criteria

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturer's recommendations and as shown.

Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified.

3.1.4 Wiring Criteria

Wiring external to control panels, including low-voltage wiring, shall be installed in metallic raceways. Nonmetallic-sheathed cables or metallic-armored cables may be installed in areas permitted by NFPA 70. Wiring shall be installed without splices between control devices and DDC panels. Instrumentation grounding shall be installed as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings.

3.2 CONTROL SYSTEM INSTALLATION

3.2.1 Risk Management Framework Installation Certification

Furnish a certification packet that demonstrates and certifies that control systems are installed and tested in accordance with DoD Instruction 8500.01, DoD Instruction 8501.01, and as defined by Section 01 91 10.01 29 CYBERSECURITY/RISK MANAGEMENT FRAMEWORK REQUIREMENTS.

3.2.2 Damper Actuators

Actuators shall not be mounted in the air stream unless plenum rated. Multiple actuators operating a common damper shall be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.3 Room Instrument Mounting

Room instruments, such as wall mounted thermostats, shall be mounted 48 inches above the floor unless otherwise shown. Temperature setpoint devices shall be recess mounted.

3.2.4 Freezestats

For each 20 square feet of coil face area, or fraction thereof, a freezestat shall be provided to sense the temperature at the location shown. Manual reset freezestats shall be installed in approved, accessible locations where they can be reset easily. The freezestat sensing element shall be installed in a serpentine pattern.

3.2.5 Duct Static Pressure Sensing Elements and Transmitters

The duct static pressure sensing element and transmitter sensing point shall be located at 75% to 100% of the distance between the first and last air terminal units.

3.3 CONTROL SEQUENCES OF OPERATION

All sequences of operation will be covered under each drawing package.

3.4 COMMISSIONING PROCEDURES

3.4.1 Evaluations

The Contractor shall make the observations, adjustments, calibrations, measurements, and tests of the control systems, set the time schedule, and make any necessary control system corrections to ensure that the systems function as described in the sequence of operation.

3.4.1.1 Item Check

Signal levels shall be recorded for the extreme positions of each controlled device. An item-by-item check of the sequence of operation requirements shall be performed using Steps 1 through 4 in the specified control system commissioning procedures. Steps 1, 2, and 3 shall be performed with the HVAC system shut down; Step 4 shall be performed after the HVAC systems have been started. External input signals to the DDC system (such as starter auxiliary contacts, and external systems) may be simulated in steps 1, 2, and 3. With each operational mode signal change, DDC system output relay contacts shall be observed to ensure that they function.

3.4.1.2 Weather Dependent Test Procedures

Weather dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the actual results shall be verified in the appropriate season.

3.4.2 Space Temperature Controlled Perimeter Radiation

The heating medium shall be turned on, and the thermostat temperature setpoint shall be raised. The valve shall open. The thermostat temperature shall be lowered and the valve shall close. The thermostat shall be set at the setpoint shown.

3.4.3 Unit Heater and Cabinet Unit Heater

The "OFF/AUTO" switch shall be placed in the "OFF" position. Each space thermostat temperature setting shall be turned up so that it makes contact to turn on the unit heater fans. The unit heater fans shall not start. The "OFF/AUTO" switch shall be placed in the "AUTO" position. It shall be ensured that the unit heater fans start. Each space thermostat temperature setting shall be turned down, and the unit heater fans shall stop. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.4.4 Fan Coil Unit

The dual-temperature hydronic system shall be set to heating. Each space thermostat temperature setting shall be turned up so that it makes contact and turns the fan coil unit on. It shall be ensured that the fan coil unit fan starts and the valves open to flow through the coils. Each space thermostat temperature setting shall be turned down and it shall be ensured that the fan coil unit fans stop. It shall be ensured that the valves close to flow through the coils. The dual-temperature hydronic system shall be switched to cooling. Each space thermostat temperature setting shall be turned up and it shall be ensured that contact is broken and the fan coil unit fans stop. It shall be ensured that the valves close to flow through the coil. Each space thermostat temperature setting shall be turned down. It shall be ensured that the fan coil unit fans start and the valves open to flow through the coils. The thermostats shall be set at their temperature setpoints. The results of testing of one of each type of unit shall be logged.

3.4.5 Hydronic Heating with Hot Water Boiler

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air temperature and system supply temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all valves shall be verified visually. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) The two-point calibration sensing element-to-DDC system readout accuracy check for the outside air temperature shall be performed. Any necessary software adjustments to setpoints or parameters shall be made to achieve the outside air temperature schedule.

(2) The return hot water temperature shall be simulated through an operator entered value to be above the setpoint. It shall be verified that pumps and boiler stop. A value shall be entered to simulate that the return hot watertemperature is below the setpoint as shown. It shall be verified that pumps start and boiler operates.

(3) The two-point calibration accuracy check of the sensing element-to-DDC system readout for the hydronic system supply temperature shall be performed. The supply temperature setpoint shall be set for the temperature schedule as shown. Signals of 8 ma and 16 ma shall be sent to the DDC system from the outside air temperature sensor, to verify that the supply temperature setpoint changes to the appropriate values.

(4) The control system shall be placed in the occupied mode. The calibration accuracy check of sensing element-to-DDC system readout shall be performed for each space temperature sensor and the values logged. Each space temperature setpoint shall be set as shown. The control system shall be placed in the unoccupied mode, and it shall be verified that each space temperature

setpoint changes to the unoccupied mode setting.

3.4.6 Heating and Ventilating Unit

Steps for installation are as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air damper and relief air damper are closed, and the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system readings logged. The calibration accuracy of the sensing element-to-DDC system readout for space temperature shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be verified. The signal shall be varied from live zero to full range, and that the actuators travel from zero stroke to full stroke within the signal range shall be verified. It shall be verified that all sequenced and parallel-operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the system shall be placed in the ventilation delay mode and in the occupied mode through operator entered values. It shall be verified that supply fan starts. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the heating coil valve is under control, by artificially changing the space temperature through operator entered values. The system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control by simulating a change in space temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The calibration accuracy check of sensing element-to-DDC system readout for the space temperature shall be performed. The space temperature setpoint shall be set as shown.

(4) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set as shown.

(5) With the HVAC system running, a filter differential pressure switch input signal shall be simulated, at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(7) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and verification of control device actions and interlock functions as described in the Sequence of Operation shall be made. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm signal is changed to a return-to-normal signal.

3.4.7 Variable Air Volume Control System - With Return Fan

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be observed in its shutdown condition. It shall be verified that power and main air are available where required, and that the outside air and relief air dampers are closed, the return air damper is open, and that the supply fan and return/relief fan inlet vanes and cooling coil valve are closed.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, mixed air, and cooling coil discharge temperatures shall be checked. The minimum outside air flow, supply air flow, and return air flow shall be read, using a digital indicating velometer, and the velometer and DDC system display readings logged. The flows should read zero.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuators through an operator entered value at the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero to full range, and actuator travel shall be verified from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

d. Step 4 - Control System Commissioning:

(1) With the fans ready to start, the control system shall be

placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan and return fan start. It shall be verified that the outside air dampers and relief air damper are closed, the return air damper is open, and the cooling coil valve and inlet vanes are under control, by simulating a change in the fan discharge temperature. The system shall be placed out of the ventilation delay mode, and it shall be verified that the economizer outside air and relief air dampers remain closed, the return air damper remains open, and the minimum outside air damper comes under control.

(2) The two-point calibration accuracy check of sensing element-to-DDC system readout for the minimum outside air flow measurement station shall be performed. Force all VAV box dampers to the full open position, turn all exhaust fans off, manually adjust the supply duct static pressure to achieve the design duct static pressure, manually adjust the output to the return fan to establish the design differential flow difference between the supply and return duct flows, and manually adjust the minimum outside air flow to achieve a flow which is approximately 25% less than the desired air flow. Under these conditions, the minimum outside air flow control loop shall be tuned. Confirm stable operation of the minimum outside air flow control loop in response to a process disturbance.

(3) The VFD of return fan shall be turned to the "OFF" position, and the inlet vane damper shall be opened. With supply fan running, a high static pressure input signal shall be simulated at the device by a pressure input to the sensing device. HVAC system shutdown shall be observed, and it shall be verified that the high static alarm is initiated. The HVAC system shall be restarted by manual reset, and it shall be verified that the high static alarm returns to normal.

(4) The two-point accuracy check of sensing element-to-DDC system readout for the static pressure in the supply duct shall be performed.

(5) Each VAV terminal unit controller's minimum flow and maximum flow setpoints shall be set at the same setting. This will prevent the VAV box damper from modulating under space temperature control and will achieve a constant supply duct system pressure drop. The return fan speed shall be placed under control, and the VFD switch shall be turned to the "AUTO" position so that the fan starts. The two-point calibration accuracy check of sensing element-to-DDC system readout for the air flow measurement stations shall be performed. The supply fan speed shall be operated manually to change the supply fan flow, and the control system shall be set to control at minimum cfm at 4-ma input and maximum cfm at 20-ma input. The supply fan flow shall be changed to verify that the return flow setpoint tracks the supply fan flow with the proper flow differential.

(6) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The mixed air temperature shall be artificially changed through operator entered values to slightly open the economizer outside air damper and the second point of the

two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and mixed air temperatures shall be performed. The temperature setpoint shall be set as shown.

(7) The two-point calibration accuracy check of sensing element-to-DDC system readout for the fan discharge temperature shall be performed. The setpoint for the fan discharge temperature shall be set as shown. A change shall be simulated in the discharge air temperature through an operator entered value and it shall be verified that the control valve is modulated.

(8) The control system shall be placed in the unoccupied mode and it shall be verified that the HVAC system shuts down and the control system assumes the specified shutdown conditions. The space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback temperature setpoint and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint.

(9) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown. This shall be performed for each filter.

(10) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low temperature alarm is initiated. The freezestat shall be set at the setpoint as shown. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(11) With the HVAC system running, a smoke detector trip input signal shall be simulated at each device. Control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and the alarm return-to-normal shall be verified.

(12) For each VAV terminal unit, velocity setpoints shall be set for minimum and maximum flow, and temperature setpoints for the heating/cooling dead band. The actions of the controller, the operation of the damper, and the operation of heating shall be verified. It shall be verified that space temperature is maintained.

3.4.8 Single Zone with Hydronic Heating Direct Expansion Cooling

Steps for installation shall be as follows:

a. Step 1 - System Inspection: The HVAC system shall be verified in its shutdown condition. The system shall be checked to see that power and main air are available where required, the outside air damper and relief air damper are closed, all stages of cooling are off, and that the return air damper is open.

b. Step 2 - Calibration Accuracy Check with HVAC System Shutdown: Readings shall be taken with a digital thermometer at each temperature sensing element location. Each temperature shall be read at the DDC controller, and the thermometer and DDC system display readings logged. The calibration accuracy of the sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be checked.

c. Step 3 - Actuator Range Adjustments: A signal shall be applied to the actuator, through an operator entered value to the DDC system. The proper operation of the actuators and positioners for all dampers and valves shall be visually verified. The signal shall be varied from live zero of 4 ma to 20 ma, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. It shall be verified that all sequenced and parallel operated actuators move from zero stroke to full stroke in the proper direction and move the connected device in the proper direction from one extreme position to the other. Example: NC actuators are closed at 4 ma and are open at 20 ma. The signal levels that move the controlled device to its extreme positions shall be logged. The operating points of the sequence shall be set for each stage of cooling and the proper operation of each stage shall be verified.

d. Step 4 - Control System Commissioning:

(1) With the fan ready to start, the control system shall be placed in the ventilation delay mode and in the occupied mode, and it shall be verified that supply fan starts. It shall be verified that the outside air and relief air dampers are closed, the return air damper is open, and the heating coil and stages of cooling are under control, by simulating a change in the space temperature. The control system shall be placed out of the ventilation delay mode, and it shall be verified that the outside air, return air, and relief air dampers come under control by simulating a change in the mixed air temperature.

(2) The control system shall be placed in the minimum outside air mode. It shall be verified that the outside air damper opens to minimum position.

(3) The economizer mode shall be simulated by a change in the outside air temperature and the return air temperature through operator entered values and it shall be verified that the system goes into the economizer mode. The space temperature shall be artificially changed through operator entered values to slightly open the outside air damper and the second point of the two-point calibration accuracy check of sensing element-to-DDC system readout for outside air, return air, and space temperatures shall be performed. The space temperature setpoint shall be set as shown. A change in space temperature shall be simulated and it shall be verified that the heating coil valve and the stages of D/X cooling operate in sequence as shown.

(4) The control system shall be placed in the unoccupied mode, and it shall be verified that the HVAC system shuts down, and the control system assumes the specified shutdown conditions. The

space temperature shall be artificially changed to below the night setback temperature setpoint, and it shall be verified that the HVAC system starts; the space temperature shall be artificially changed to above the night setback temperature setpoint, and it shall be verified that the HVAC system stops. The night setback temperature setpoint shall be set at the setpoint as shown.

(5) With the HVAC system running, a filter differential pressure switch input signal shall be simulated at the device. It shall be verified that the filter alarm is initiated. The differential pressure switch shall be set at the setpoint as shown.

(6) With the HVAC system running, a freezestat trip input signal shall be simulated at the device. HVAC system shutdown shall be verified. It shall be verified that a low-temperature alarm is initiated. The freezestat shall be set at the setpoint. The HVAC system shall be restarted by manual restart and it shall be verified that the alarm returns to normal.

(7) With the HVAC system running, a smoke detector trip input signal shall be simulated at each detector, and control device actions and interlock functions as described in the Sequence of Operation shall be verified. Simulation shall be performed without false-alarming any Life Safety systems. It shall be verified that the HVAC system shuts down and that the smoke detector alarm is initiated. The detectors shall be reset. The HVAC system shall be restarted by manual reset, and it shall be verified that the alarm returns to normal.

3.5 BALANCING, COMMISSIONING AND TESTING

3.5.1 Coordination with HVAC System Balancing

Commissioning of the control system, except for tuning of controllers, shall be performed prior to or simultaneous with HVAC system balancing. The contractor shall tune the Building Management System after all air system and hydronic system balancing has been completed, minimum damper positions set and a report has been issued.

3.5.2 Control System Calibration, Adjustments and Commissioning

Control system commissioning shall be performed for each HVAC system, using test plans and procedures previously approved by the Government. The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to support commissioning and testing of the Building Management System. Wiring shall be tested for continuity and for ground, open, and short circuits. Tubing systems shall be tested for leaks. Mechanical control devices shall be adjusted to operate as specified. Communications requirements shall be as indicated. Written notification of any planned commissioning or testing of the Building Management System shall be given to the Government at least 14 calendar days in advance.

3.5.3 Performance Verification Test

The Contractor shall demonstrate compliance of the Building Management System with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Commissioning Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems.

3.5.4 Endurance Test

The endurance test shall be used to demonstrate the specified overall system reliability requirement of the completed system. The endurance test shall not be started until the Government notifies the Contractor in writing that the performance verification test is satisfactorily completed. The Government may terminate the testing at any time when the system fails to perform as specified. Upon termination of testing by the Government or by the Contractor, the Contractor shall commence an assessment period as described for Phase II. Upon successful completion of the endurance test, the Contractor shall deliver test reports and other documentation as specified to the Government prior to acceptance of the system.

a. Phase I (Testing). The test shall be conducted 24 hours per day, 7 days per week, for 15 consecutive calendar days, including holidays, and the system shall operate as specified. The Contractor shall make no repairs during this phase of testing unless authorized by the Government in writing.

b. Phase II (Assessment). After the conclusion of Phase I, the Contractor shall identify failures, determine causes of failures, repair failures, and deliver a written report to the Government. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which testing should be resumed. After delivering the written report, the Contractor shall convene a test review meeting at the jobsite to present the results and recommendations to the Government. As a part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing appropriate portions of the performance verification test. Based on the Contractor's report and test review meeting, the Government may require that the Phase I test be totally or partially rerun. After the conclusion of any retesting which the Government may require, the Phase II assessment shall be repeated as if Phase I had just been completed.

3.5.5 Posted and Panel Instructions

Posted and Panel Instructions, showing the final installed conditions, shall be provided for each system. The posted instructions shall consist of laminated half-size drawings and shall include the control system schematic, equipment schedule, sequence of operation, wiring diagram, communication network diagram, and valve and damper schedules. The posted instructions shall be permanently affixed, by mechanical means, to a wall near the control panel. Panel instructions shall consist of laminated letter-size sheets and shall include a Routine Maintenance Checklist and as-built configuration check sheets. Panel instructions and one copy of the Operation and Maintenance Manuals, previously described herein, shall be placed inside each control panel or permanently affixed, by mechanical means, to a wall near the panel.

3.6 TRAINING

3.6.1 Training Course Requirements

A training course shall be conducted for operating staff members designated by the Contracting Officer in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of 32 hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site. Audiovisual equipment and six sets of all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.6.2 Training Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each HVAC control panel, the layout of one of each type of unitary equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, and repair procedures. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the calibration, adjustment and commissioning report shall be presented as benchmarks of Building Management System performance by which to measure operation and maintenance effectiveness.

-- End of Section --